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BEHAVIORAL EVALUATION OF A WINTER WARFARE TRAINING EXERCISE, 19--ETC(U)
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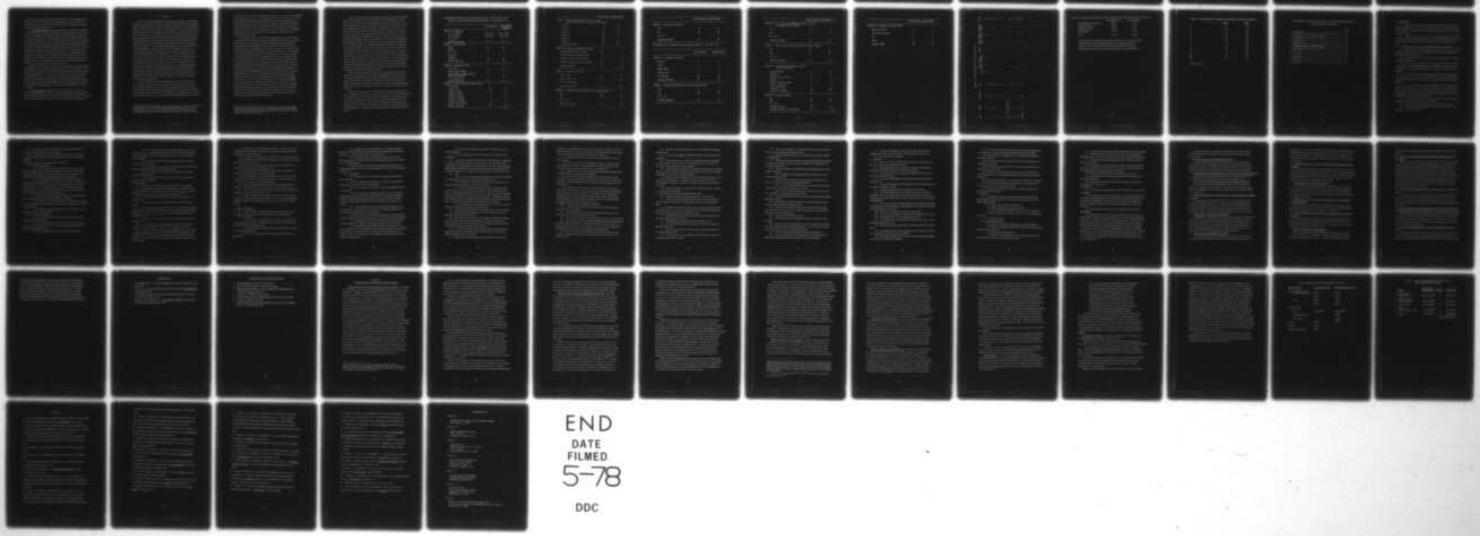

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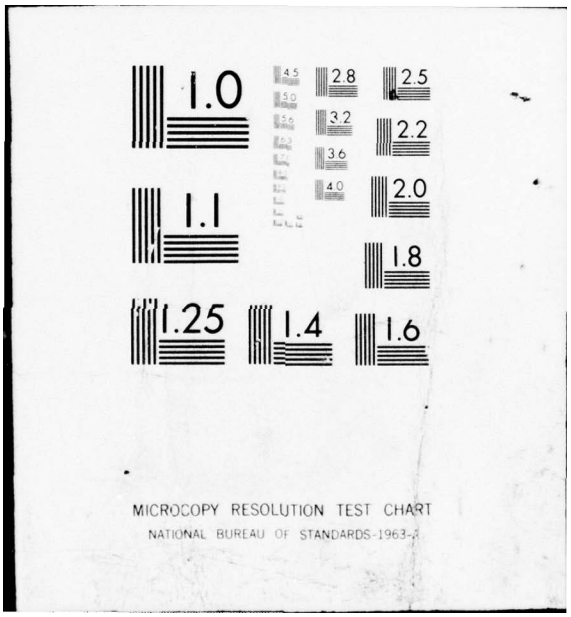
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REPORT NO T 1/78 (13)

BEHAVIORAL EVALUATION OF A WINTER WARFARE TRAINING EXERCISE, 1977

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts

OCTOBER 1977

UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

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Behavioral Evaluation of a Winter Warfare Training Exercise, 1977

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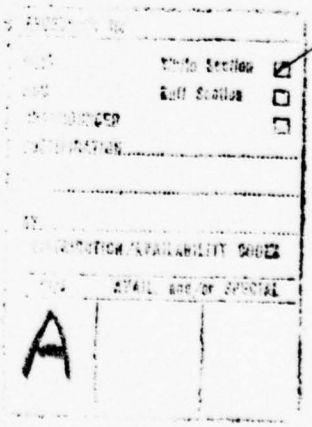

FOREWORD

This report provides an estimate of the medical costs of winter warfare training. These results should be treated as our conclusions based on a single field study. The reader will note that this report contains a large section of responses to a standard interview. The conclusions are those of the people "in the field", from Sergeants to Colonels. The reader is offered the benefit of their opinion. Many of these people felt there was no way in which they could let their opinion be known or share their accumulated experience with others equally interested in cold weather warfare. We realize the reader may have questions and disagreements with some of their statements. However, we felt it was better to include these controversial statements in order to show the way things really are in the field -- people do not always agree. We have agreed to keep their responses anonymous, but would like to thank each person who agreed to be interviewed. We thank the reader for his time in reading this report and hope it proves useful in dealing with some of the human problems encountered in cold weather training and warfare. We would be interested in the opinions of readers whether they agree or disagree with our conclusions and whether this report is helpful.

Special thanks go to Major Ronald E. Jackson and Captain Robert N. Spencer for reading this report and making helpful comments and to Major Gaither D. Bynum for collecting the sick call data and assisting with the conduct of the study.

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ABSTRACT

A field study was conducted to define the effects of environmental cold stress on the individual and group performance of US Army soldiers undergoing infantry training. Observations were made on individual and unit performance, incidence and type of medical problems and social organization and how social factors affect unit performance and health. Interviews were obtained from experienced individuals. Conclusions and recommendations were made regarding winter warfare training.

INTRODUCTION

The devastating effects of low environmental temperatures on military operations has been documented from the time of the Greeks[4]. Cold injuries have been reported in every major conflict in which the United States has been involved including Vietnam*. The military and economic cost of cold injuries has been staggering. Total allied casualties in World War I, World War II and Korea exceeded 1.0 million cases. Of the 90,535 U. S. Army personnel admitted with cold injuries (2/3 trenchfoot, 1/3 frostbite) during World War II, 47,847 were primary injuries (classified as non-battle injuries) with an average hospital stay of 56.03 days and a mean noneffective duty time of 131 days. This represents 2.68 million hospital man-days (7345 hospital man-years) and 6.27 million man-days (17,172 man-years) lost from duty time, respectively. The hospital cost ($138.50/day alone for the primary cold injuries) is estimated to have reached $371.2 million. In terms of the loss of combat strength, these same injuries equalled the loss of an entire division for 1.14 years. Although the high incidence of secondary cold injuries (42,688 primary battle injuries) which occurred following combat-induced trauma in World War II were not equally preventable, a more responsive cold weather evacuation system could have reduced the incidence of these secondary injuries.[3]

Cold injury is considered a preventable condition. The fundamental principles of cold injury prophylaxis were developed by the British in World War I[4]. These principles included maintaining physical fitness and hygienic conditions, protection of the feet and legs from wet and cold, and provision of hot food. Supervision by leaders of foot hygiene was found to be a key to success. Studies done in Europe during World War II showed that cold injury is a component of mass trauma and that it can be subjected to an epidemiologic analysis using agent, host and

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*Two hypothermia cases occurred in the I Corps area of the Republic of Vietnam among Special Forces troops operating in the highlands. (Personal communication, SGM James T. Heath, US Army).

environmental factors. The agent conditions, which must be present for cold injury to occur, are cold or cold-wet and time. Time refers here to exposure which has two components, degree and duration. The host is man. The host factors are human qualities which predispose or protect him against injury. Some of these in the case of cold injury are things such as fatigue, nutritional status, age, race, geographic origin, morale and previous cold injury. The environmental factors refer to conditions outside man including physical, biological and socioeconomic factors which bring together the agent and the host. In the case of cold injury, significant environmental factors include terrain, altitude, type of combat action, clothing and equipment, shelter, command leadership, discipline and training. The causation of cold injury is complex because of the interactions among these factors. The reader is referred to Whayne and DeBakey[4] for an excellent discussion of this topic.

There are many overwhelming problems the field commander must contend with in the cold. These include such problems as the effect of low temperature on vehicles, batteries, communications equipment, weapons, the loss of air mobility, movements of troops and supplies, altered work-rest cycles, limitation due to shorter daylight periods and medical problems. The magnitude of such difficulties often tends to overshadow the human problems of operating in the cold. The U.S. Army Cold Regions Test Center has recently published a Cold Regions Primer which outlines the basic problems of the field commander in cold such as logistics, material, communications, and others[1].

Solution of medical problems in the Arctic has never been attempted in terms of a consolidated program. Joy noted problems in the functions of large numbers of men in the cold and the difficulties of the medical service in finding, evacuating, and treating cold injury casualties.[2] Little has changed since this report in terms of clothing, equipment, treatment and medical doctrine.

Our investigation was an attempt to look at these many interacting factors as they occurred naturally in the field and to document them in a single paper. By so doing we hope to make this knowledge available to others who will be operating in a cold environment.

BACKGROUND OF THE FIELD STUDY

An observational field investigation was conducted to define the effects of environmental stress (cold weather) on the individual and group performance of U.S. Army soldiers undergoing infantry training. An infantry battalion conducted winter warfare training under the Army Readiness Training and Evaluation Program (ARTEP). This two week training period included the basics of skiing, oversnow movement of units, ahkio pulling, use of the ten man arctic tent and Yukon stove, winter tactics, and living in the field for a three day and three night bivouac.

The purpose of the study was to observe the effect of cold stress on: (1) individual and unit performance; (2) incidence and type of medical problems; and, (3) social organization and how social factors affect unit performance and health. Within this framework, an attempt was made to answer the following key questions:

1. How does cold affect the personal habits of soldiers and their ability to perform?
2. Is cold weather itself stressful to individuals?
3. Which "lifestyles" seem to be conducive either to performing well or poorly in the cold?
4. How knowledgeable is the individual soldier of the effects of cold upon him and of protective care measures to follow when in a cold environment?
5. What are the physiological effects of cold on individuals performing in the field?
6. What are the physical demands of winter warfare training on individuals?
7. What are the attitudes and practices of individuals with regard to the use of alcohol in the cold?
8. Did the medical support unit receive sufficient cold weather medical training to be able to function effectively?
9. How does cold affect the medical delivery system?
10. Is medical doctrine altered in order to provide medical care in a cold environment?

11. Are the force structures for medical support adequate in the cold?

12. How do casualties affect the performance of a unit and its ability to complete its mission?

13. How is tactical doctrine applied in the cold?

14. What seem to be the critical factors enabling a unit to work effectively in the cold?

15. What happens in a true emergency situation?

METHODS

The study was directed toward behavior in the field and used the tools of field anthropology for data collection: participant observation, interviews, questionnaires, and a survey of the troops.

Five military investigators conducted the study: a physician, a physiologist-veterinarian, a psychologist, and 2 medical specialists.

The battalion strength at the time of the exercise was 480. The organization consisted of a Headquarters and Headquarters Company, three Rifle Companies, and a Combat Support Company (CSC) (anti-tank, heavy mortars and scouts). One of the Rifle Companies and the CSC were observed during the exercise.

1. Interviews. Personal interviews were conducted with members of the battalion, evaluators, support personnel and visitors. All persons interviewed had previous experience in cold weather military operations. The following list provides a breakdown of the individuals interviewed:

Colonel	3
Lieutenant Colonel	9
Major	4
Captain	4
Lieutenant	3
Sergeant Major	1
First Sergeant	1
Sergeant First Class	1
Staff Sergeant	3
	29

The interviewers asked the following questions of everyone in addition to specific questions of particular individuals:

1. Background. What special qualifications or experiences do you have in winter warfare training?

2. Training. What kind of training is being conducted? Who is responsible for it? What is being done to improve training?

3. Leadership and Command Structure. How does leadership work in the cold? When does command structure break down? How is control maintained in the cold?

4. Physical Fitness. What is being done to physically prepare the soldier for winter training? What can be done to improve it?

5. Food. How important is the diet in a cold weather exercise?

6. Alcohol. Do troops consume alcohol during a cold weather field exercise? What problems occur because of its use?

7. Medical Support. Is the medical training adequate? Is the medical support adequate?

8. Medical Problems. What are the major health problems encountered during a cold weather exercise?

9. Tactical Problems. What are the major tactical problems encountered during a cold weather exercise?

10. Operational Problems. What are the major operational problems encountered during a cold weather exercise?

11. Clothing and Equipment. What problems with clothing and equipment have the troops identified? What improvements could be made?

12. Survival Training. Is survival training taught? How could it be improved? Is it of value to an infantry unit?

2. Questionnaires. Questionnaires were completed by most members of one Rifle Company and the CSC prior to and after the training. No bias was known to be operating in favor of the ones who were present. The purposes of the first questionnaire were to acquire demographic data, (for possible later comparisons with other populations) determine attitudes toward cold weather, and to obtain medical histories regarding cold weather. The second questionnaire was used to determine the range of experiences encountered by the troops during the training and the extent of their medical complaints. Specific questions asking the troops

to make choices for leaders and fellow team members if a cold weather survival situation occurred were included in both questionnaires. These data were collected in order to evaluate the social cohesion of the small units and to identify individuals having great influence.

3. Participant observers. Participant observers were located in different companies and platoons during the training and the bivouac phase. These persons were free to observe and ask questions. No individual was uniquely identified as a source of information. Observers were instructed to pay particular attention to task (on-duty) behavior in terms of adherence to military doctrine, participation in training activities, how leaders maintained individual and group performance, influence of informal leaders (persons having influence because of social factors) on performance of tasks, and the equitable distribution of military duties. Non-task (off-duty) behaviors which were likely to affect the way people performed on duty were also observed. These behaviors included comparison of social organization during off-duty evening time compared to duty time, social constraints on behavior, meals and eating patterns, affective (feeling) states and personal habits which may have affected the ability to perform.

Observers were also instructed to pay special attention to stressful situations to determine: (1) how individual and unit performance was affected; (2) how well people cope and with the harsh, cold weather; (3) what seemed to be the critical variables responsible for a unit doing well or poorly; and, (4) what were the personal reactions of people to the situation. Proper wear and utilization of military and non-military clothing and equipment as they affected a soldier's health and feeling of well-being were also observed. Observation keys were complaints of troops and the observed adequacy of clothing and the soldier's ability to wear it correctly.

4. Sick call records. Dispensary sick call records (Table 17) served as a basis of comparison between official records, field observations and self-reports of troops on the questionnaires. These were used to estimate the need for treatment and to determine why cases were or were not entered into the medical system.

RESULTS

There were many differences observed in the two companies . The average age (Table 1) of members of the Rifle Company was older than that of the Combat Support Company and more members of the Rifle Company were married (Table 2). Neither of these differences was statistically significant.* There was a statistically significant difference in the educational level of the two companies (See Table 3), but these differences did not appear to have any bearing on the unit's performance. Most of the people were from small towns (See Table 4) and had lived their entire lives in the northern United States where cold winters are the rule (See Table 5). Despite this similarity of backgrounds, the attitudes toward cold were different in the two companies. It was thought that this difference may have been related to the age difference. However, a point-biserial correlation coefficient was computed between age and the response to the statement "I enjoy/do not enjoy cold weather" and found not to be significant ($r_{p-b} = .016$) indicating that there was no such relationship in this sample. It may be that those persons who liked cold weather joined the CSC by chance or that the esprit de corps of the unit was high enough to override personal comfort factors. The higher spirit of the CSC was readily apparent to the participant observers. Another possible explanation is that members of the Rifle Company were people who had been forced to deal with cold weather in their daily lives (in rural areas) whereas the CSC people were from larger towns and had spent more time indoors. Thus the CSC people may have viewed the 2 week training more as a recreational event than did the Rifle Company people.

It should be noted that this population had been exposed to cold weather for many years (Table 5) and many individuals had attended previous winter warfare training, (Table 6) (47% for both the Rifle Company and the CSC of those answering the questionnaire). Despite the degree of previous training, most people were still bothered with cold hands and feet (Table 8). Although a history of serious cold injury (Table 9) was low, many of those individuals had experienced or claimed

*The Chi-Square test of statistical significance was used to determine if differences observed were due to chance. When a probability value (p) is reported it means the likelihood of such an event occurring by chance is less than or equal to the value reported (for example, 0.05 means the likelihood is only 5 times out of 100).

to have had a mild frostbite and thought very little of it -- it was viewed as something to be expected when exposed to cold for long periods of time. Despite the severity of the cold (See Table 19) only about half the troops reported suffering physical discomfort during the training (See Table 13). The type of discomfort was specific to each company (See Table 14) with the Rifle Company reporting more cold discomfort than the CSC. The major complaint of the CSC was discomfort associated with the lack of food. Lack of liquids in the field and at meal times was also reported by both companies.

The importance of food as a morale factor during the exercise was evident to all the participant observers. It is clear that the importance of food and liquids should be kept in mind by anyone planning cold weather training, if high motivation and optimal effectiveness are to be maintained. The importance of hot meals must be continually emphasized. These are occasions when a master menu calls for the serving of cold food (such as cold cut sandwiches). It is recommended that particular attention be given to the planning of winter menus such that the serving of hot food is maximized. Interestingly, there were many myths among the troops about food, particularly about the number of calories required during cold weather operations. Many individuals were of the impression that 5,000 - 7,000 kilocalories (kcal)* were required as a minimum per day to meet the energy expenditure of the exercise. Four thousand kcal/man/day should be adequate for nearly all troops undergoing normal (i.e., not exhausting) winter military training (Appendix A). Persons with jobs requiring minimal physical activity (e.g., supply room) would not require the higher caloric intake of troops undergoing strenuous winter training. It was also evident that the troops made a judgment as to whether the effort required to go to the mess tent would be sufficiently rewarded (See Tables 15 and 16). Many people chose to remain in their sleeping bag or tent rather than go for food. A tremendous amount of candy and snack food was carried to the field with the intention of eating it in the comfort of the tent. Specific complaints included lack of liquids during meals, the lack of sufficient water points, and the lack of hot food.

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*The kilocalorie (kcal), a unit of heat, is approximately the quantity of energy necessary to raise one kilogram of water one degree Celsius (or one pint, 4°F). A kcal is equal to 1000 calories or one Calorie. The calories referred to in food tables are actually kcals or Calories.

The sick call data (See Table 17) showed the commonness of minor disorders such as upper respiratory infections (colds) and musculoskeletal injuries from skiing. Although none was recorded during this exercise, the possibility of heart attacks, especially among older, less physically fit persons, must be kept in mind and contingency plans made for emergency treatment and evacuation. It is imperative that dispensaries be equipped with appropriate equipment and drugs to meet all medical emergencies even though the incidence of such events is low. Incidence rates were calculated from the sick call records provided by the dispensary (See Table 18). Rates were calculated on the basis of a total population of 480 and are expressed in per 1000 per two weeks and per 1000 per day (total for 1-1/2 weeks divided by 9). Many people reported an illness or injury during training. The majority of these were not reported to the medics (See Tables 11 and 12). Most of these complaints were for chest colds, muscular soreness and cold discomfort which were not severe enough to require treatment. However, the total injury rate seen at sick call per day was about 4%. The untreated illness rate was higher. The high rate of upper respiratory infections (Table 18) indicates many of the preventive medicine problems that are involved in winter warfare training. The humidity is generally low, barracks are crowded, overheated and full of drafts. This, along with dehydration produced by lack of water, produces conditions conducive to the spread of infection.

Another medically related problem that is not directly reflected in these statistics is the prevalence of overheating. Overheating was primarily due to the improper wearing of clothing. Medically, overheating can lead to such conditions as hypothermia, frostbite, heat illness (heat stroke or exhaustion) and death. Overheating which produces casualties in the field is a potentially serious problem for the unit in that the person must be evacuated or allowed to dry his clothing.

These medical data show that while most of the problems encountered in this training were minor from a medical point of view they will cause a fair amount of time being lost from training. Although the incidence of major medical problems was low, the potential remains high for very serious consequences. Such problems are heart attacks, major fractures, dehydration, severe frostbite and hypothermia. The best way to approach such a situation is with a good preventive medical program and a realization of the potential minor and major medical problems.

QUESTIONNAIRE RESULTS: Number in Rifle Company = 109, in CSC = 81. For Tables 1 - 9, Number surveyed for Rifle Company N = 77, for CSC N = 32.

	Rifle Company	Combat Support Company
TABLE 1. Average Age		
E-5 and below	25.44 (61)	22.12 (26)
E-6 and above	34.56 (16)	28.0 (6)
$\chi^2 = 1.63$		
Number answering	77	32
TABLE 2. Marital Status		
Single	27	15
Married	50	14
$\chi^2 = 1.80$		
Divorced	0	1
Separated	0	1
Number answering	77	31
TABLE 3. Educational Status		
Grade 9-11	9	5
High School Graduate	53	15
Some college, College Graduate, Advanced Education	13	10
$\chi^2 = 4.28$ ($p < .05$)		
Number answering	75	30
TABLE 4. Size of Town Spent Most Time In		
Farm/Ranch	19	7
5,000 or less	43	9
5,000 to 10,000	11	2
10,000 to 50,000	0	11
50,000 to 100,000	0	1
100,000 to 500,000	0	1
Greater than 500,000	0	1
Number answering	73	32

	Rifle Company	Combat Support
TABLE 5. How long have you lived in this climate (Mild or hot summers, cold or very cold winter)		
1-10 yrs	0	2
11-15 yrs	1	0
16-20 yrs	19	12
21-25 yrs	22	10
26-30 yrs	15	5
31-35 yrs	10	1
36-55 yrs	9	0
Number answering	76	30
TABLE 6. Previous Cold Weather Training		
Cold Weather Infantry Training	28	14
Northern Warfare Training Center	3	0
Other (Korea, Germany, Japan)	5	1
Number who had previous cold training	36	15
Number surveyed	77	32
TABLE 7. Attitude Toward Cold		
Enjoy Cold	22	22
Do not enjoy cold	43	6
$\chi^2 = 13.96$ ($p<.001$)		
Number answering	65	28
TABLE 8. Bothered with Cold Hands or Feet in Cold Weather		
Yes	65	21
No	10	8
$\chi^2 = 2.06$		
Number answering	75	29

	Rifle Company	Combat Support
TABLE 9. Ever Had a Cold Injury		
Yes	18	6
No	46	22
$\chi^2 = 0.17$		
Number answering	64	28

For Tables 10-16. Number Surveyed for Rifle Company N = 69, CSC = 65

	Rifle Company	Combat Support
TABLE 10. Training of Most Value		
Survival	6	13
Field	6	4
Night Patrol	3	0
Mortar Firing	3	7
Ski Training	30	21
Number answering	48	45
TABLE 11. Reported Having Illness or Injury During Training		
Yes	19	10
No	46	34
$\chi^2 = 0.28$		
Number answering	65	44

	Rifle Company	Combat Support
TABLE 12. If an Injury was Reported in Table 11, was it also Reported to the Medics		
Yes	12	5
No	7	5
$\chi^2 = 0.08$		
Number answering	19	10
TABLE 13. Did you Suffer Physical Discomfort During Training		
Yes	30	21
No	25	22
$\chi^2 = 0.13$		
Number answering	55	43
TABLE 14. If Discomfort Reported in Table 13, Type of Discomfort		
Cold Discomfort	17	10
Exhaustion	5	0
Hunger or Lack of Food	4	21
Soreness	5	1
Thirst or Lack of Liquids	7	3
Lack of Cleanliness	1	2
Crowding in Tents	1	2
Number of Complaints	40	39
TABLE 15. Missed any Meals		
Yes	21	10
No	33	20
$\chi^2 = 0.07$		
Number answering	54	30
Averaged number of meals missed	4.0	3.05

	Rifle Company	Combat Support
TABLE 16. If Meals were Missed, Why?		
Ran out of food	5	3
Not worth the effort	13	11
Ill	1	1
Tired	1	1
Number Missed	20	16

TABLE 17. BATTALION SICK CALL DAYS (2-12)

DAY	MISC	MUSCLES	URI	COLD INJURY			BURN	ORTHOPEDIC INJURIES			TOTAL
				TOE	FACE	FINGER		LEG	ANKLE	WRIST	
2	3	3	6	0	0	0	1	0	2	1	16
3	1	6	12	2	1	1	-	-	3	-	26
4	10	17	8	-	-	1	-	-	8	1	45
5	5	-	10	-	-	-	-	-	1	-	16
6	-	4	9	-	-	-	-	-	-	-	13
7	-	-	5	-	-	-	-	-	-	-	5
8 & 9 NO SICK CALL											
10	1	7	10	0	1	0	-	-	1	-	20
11	3	1	11	-	-	-	-	-	-	-	15
12	2	8	5	-	-	-	-	-	1	-	16
TOTALS	25	46	76	2	2	2	1	0	16	2	172

Table 18. Incidence Rates for Illnesses and Injuries Reported at Sick Call during the Training Period*

	Rate/1000/2 wks	Rate/1000/day
Upper Respiratory Infections	246.29	17.59
Muscular Ailments	149.07	10.65
Orthopedic Injuries	58.33	4.17
Cold Injuries	19.44	1.39
Total	473.13	33.80

*These rates were calculated by taking data from Table 17. Example: 76 URI's occurred for the 9 days sick call was held. The total population was 480. 76/480 = 0.1583. Based on 1000 this figure becomes 158.3 for 9 days and 246.29 for 14 days. The rate per day was calculated by dividing 246.29 by 14.

TABLE 19. ENVIRONMENTAL TEMPERATURES DURING TRAINING PERIOD (^{o}F)

	HIGH	LOW
1	- 5	-25
2	-18	-27
3	-15	-50
4	-20	-30
5	-15	-35
6	-10	-40
7	+ 5	-20
8	0	-25
9	-20	-40
10	-13	-35
*11	0	-10
*12	+ 8	-10
*13	+18	-10

*Bivouac in field

RESPONSES TO INTERVIEWS OF SELECTED PERSONS WITH EXPERIENCE IN COLD WEATHER OPERATIONS

I. ENVIRONMENT

1.1. The northern United States is similar in terrain and climate to many potential regions in which the U.S. Army may have to fight; e.g., Europe, Korea. It is not necessary to go to Alaska to be in an environment suitable for cold weather military training.

1.2. People who do not live or have not trained in temperatures of -20°F (-28.9°C) or lower really do not understand cold. Personal experience and familiarization with the cold are prerequisites to effective military operations in the cold.

2. PREPARATION FOR A COLD WEATHER TRAINING DEPLOYMENT

2.1. One of the most frequently mentioned points was the fact that "mental attitude" is first in importance -- a person that is unfamiliar and afraid of the cold environment will not do well.

2.2. Regardless of where a person is from, mental preparation is needed before going to the cold.

2.3. The way to accomplish this is by gaining field experience. This gives one confidence in his clothing and equipment -- the need is to teach movement, survival, tactics, vehicles, protective measures -- generally exposing troops to problems.

2.4. You convince a man that his equipment is good by giving him experience in using the equipment and operating in the field setting. Just finding that your equipment will work and that you can survive has tremendous psychological benefits.

2.5. In a cold weather training exercise people must learn proper procedures of setting up the Yukon stove and the 10-man tent, the use and care of the ahkio, correct wearing of their winter clothing, how to take care of themselves, the importance of avoiding all alcohol consumption, proper water intake to avoid dehydration and the use of the buddy system.

2.6. Small steps (successively more difficult) should be used in going from simple tasks to the complexities of survival training.

2.7. Survival training is of exceptional value for building confidence.

2.8. People in the ten man group have to look after each other. This is the best use of the "buddy system."

2.9. Physical conditioning and leadership are of great importance and must be well established prior to a cold exercise.

2.10. The importance of physical conditioning and mental attitude were mentioned by almost everyone as the key elements of effective cold weather training.

3. TRAINING DURING A COLD WEATHER EXERCISE

3.1. MEDICAL TRAINING

3.1.1. Medics need more training in basic life saving skills. They should be taught the basic skills and the situations in which they will be used. As much training as possible in the areas of first aid, survival and evacuation should be accomplished before the beginning of the training exercise.

3.1.2. Unless a medical unit has a deficiency, their training may not be supervised and tailored the way combined arms training is. Note: if combined arms teams accomplish their mission, the assumption is then made that support units must have accomplished their mission. Evaluators seem willing to assume that a medical unit does not need help unless it asks for it, but they are not willing to assume that for other types of units.

3.1.3. The amount that line people knew about medical training and duties in the cold varied from practically nothing to moderate.

3.1.4. Medics were used most frequently for support (such as sitting on the firing range, sitting in ambulances) rather than participating in the training with the troops.

3.1.5. "Medics need to be trained to operate in the cold." This was frequently stated, but rarely occurred.

3.2. MILITARY TRAINING

3.2.1. Competition is a very useful tool, particularly in building confidence during ski training.

3.2.2. The individual soldier did not really know what cold injuries were or how to minimize their occurrence. That is, the individual soldier had limited knowledge of cold injury.

3.2.3. A wide range was found in the level of physical fitness.

3.2.4. It was generally observed that older people avoided strenuous duty and were more complacent about being overweight and in poor physical condition. It was often dismissed with "people tend to put on 10-15 extra pounds as they get older."

3.2.5. Ideally, cold weather instruction should be in small groups of not more than ten people.

3.2.6. We may need some specially trained units, such as cold weather units for special deployments and for training new units.

3.2.7. Units must be trained not only to develop their MOS skills but also cold weather skills.

3.2.8. Units need to train where it is really cold if confidence and proficiency are to be obtained.

4. LEADERSHIP

4.1. Cold has a great tendency to cause deterioration in leadership.

4.2. One reason for this deterioration in leadership is thought to be due to self-preservation. That is, a leader must first overcome his own personal discomfort before he can direct his attention to the needs of his men.

4.3. Leadership is difficult because everyone becomes interested in his own survival.

4.4. The key to success is the small unit leader, at company level and below.

4.5. Having good leaders, particularly non-commissioned officers, (NCO's), at platoon and company level who know how to take care of their men will prevent most cold injuries. (In many cases NCO's are more influential than officers in fulfilling this role.)

4.6. High esprit de corp markedly improves and maintains effective unit performance.

4.7. A major problem in the cold is keeping troops active. Individuals tend to stand around in huddles -- activity is a key to warmth in the cold.

4.8. A problem of leaders in the cold is the apparent necessity of having to do many jobs themselves that would normally be done by subordinates. Some reasons for this are difficulties in communication and transportation, lessened initiative in inexperienced troops and increased responsibilities and work requirements of leaders.

4.9. Organizing a unit for cold weather training is a concern to leaders. Frequently they do not have the experience needed to assure proper protection and training in a cold environment.

4.10. Leadership is very important in limiting the consumption of alcohol.

4.11. Leadership is also important in making sure men have proper clothing and that they wear it correctly.

4.12. One of the old stand-bys of the Army, that leaders need to check their men's feet, is of extreme importance in cold.

4.13. People who panic in the cold do strange things. Be prepared for strange reactions in people who are afraid and panic.

4.14. Many people seem to feel that leadership is much more important in the cold than in temperate or hot climates, because of the potential for loss of control of the situation and ensuing serious injury.

4.15 You instill leadership by building confidence through personal experience; it shows the man that he does not have to be afraid of the unknown.

4.16. The 10-man tent group is the primary social grouping of cold weather operations. Leaders have to be aware of this.

4.17 People in a stressful cold situation will often listen to the person who has the most knowledge of cold training even if he is not the highest ranking individual. Make sure that the company level officers and NCO's are properly trained.

5. MEDICAL PROBLEMS

5.1. The most common medical problems observed during the exercise were upper respiratory infections, ankle and leg injuries and overheating.

5.2. ALCOHOL

5.2.1. Alcohol is a major problem. It should never be consumed in the cold because of its effects on judgment, reaction time, the tendency to produce sleepiness and, eventually, cooling.

5.2.2. Many troops felt that alcohol maintained their effectiveness in the cold (i.e., felt warm).

5.2.3. On the other hand, many others felt alcohol hindered their performance.

5.2.4. Regardless of the individual effects, commanders should realize that some individuals will have alcohol before, during and after an exercise. Therefore, commanders should make plans to deal with it.

5.2.5. Generally, troops were advised not to drink alcohol in the field. However, the unit leaders usually did not say anything about its use as long as it was not being abused.

5.2.6. Some cases of alcohol-induced frostbite of the throat were reported anecedotally. This is due to the consumption of alcohol at below freezing temperature.

5.3. FROSTBITE

5.3.1. The major medical concern of line people was frostbite and how to deal with it.

5.3.2. Some people felt they could have frostbite of the lungs with heavy exercise in the cold. (This is not possible.)

5.3.3. It was felt that most frostbite was caused by people not being mentally alert.

5.3.4. Not all frostbite cases are preventable. There may be cases where people are exposed for longer periods under extremely severe conditions and have no means of getting out of the situation, e.g., continuous combat operations. Self-inflicted frostbite does occur in individuals who are poorly motivated.

5.3.5. A great deal of mild, unreported "frostnip" (superficial frostbite) will occur. This frostnip can be rewarmed in the field by application of a warm hand and should present no further problem.

5.3.6. Some unreported frostbite will also occur in small unit leaders because of their greater exposure (duration) to the cold in performing their duties.

5.3.7. Some people will not report frostbite because they feel they would be letting their buddies down, especially if they had to be evacuated.

5.3.8. Improperly fitting clothing or equipment increases the risk for cold weather injury. Some persons do not know how to properly fit cold weather gear during the issue stage and time for fitting is limited. People are later reluctant to return to the issue facility. Leaders should insure that personnel have properly fitting equipment.

5.3.9. It was felt that ninety five percent of frostbite is due to individual negligence.

5.4. Other medical problems, of unknown extent, are constipation and dehydration.

5.5. Although the importance of the problem of dehydration is recognized, we observed very little emphasis on carrying water to the field, forced water consumption, or bringing water to the troops while in the field. Squad and platoon leaders should be especially conscious of noting fluid intakes by troops and watch for signs of dehydration such as brown rather than yellow urine spots in the snow.

5.6. DIET

5.6.1. There was some confusion about proper diet in the cold. People were unsure about the number of calories troops should consume.

5.6.2. Troops were observed to be eating a lot of snack food. This often prevents proper utilization of field mess facilities.

5.6.3. Mess facilities should be of high priority in planning a cold training exercise. Unless food is hot and palatable, troops frequently will not get out of their sleeping bags to go to a mess tent. After several days of skipping meals an adverse effect on morale will be clearly evident. Inadequate water and food intake may then lead to additional medical problems over the span of several days. The serving of cold food should be avoided whenever possible.

5.6.4. Some people recommended having a minimum of one hot meal a day for maintenance of unit morale and performance.

5.7. Sanitation and cleanliness are more important in winter than summer.

5.8. Personal hygiene deteriorates in the cold. People do not want to take any of their clothes off to bathe.

5.9. When troops are committed to cold weather environments for longer periods of time, moustaches should be shaved off if possible. If they are not shaved, this can lead to an inflammation of the skin (dermatitis) due to the cold and moisture. Furthermore, they can hide frostbite.

5.10. A number of individuals felt smoking should be curtailed during exposure to cold. Nicotine in tobacco causes vasoconstriction in the limbs and thereby increases the risk of cold injury.

5.11. People wear too many clothes, especially the first time out. This

apparently is a psychological effect -- a fear of getting too cold out in the field. Many people feel that a manual is necessary that will tell commanders how many layers of clothing troops should wear under various conditions.

5.12. People wearing too many clothes are usually soaked with sweat in a few minutes.

5.13. One of the most important preventive measures a person can take is to change socks frequently. The emphasis here is to keep the feet dry. The damp pair can be put inside the uniform next to the body to dry.

5.14. We did notice unit emphasis on avoiding chapped lips, sunburned skin and visual problems caused by lack of sunglasses.

5.15. Shock in the cold was recognized as an important cause of death in casualties. Because of the increased mortality rate of shock in the cold, there is a need to stop the bleeding and to get the injured into a sleeping bag and evacuated quickly.

5.16. Handling cold metal is quite common, even though it is known to cause frostbite by freezing the tissue to the metal. Many units do not know about the Army's Anticontact glove, (reference CTA 50-900 C1 dtd 29 August 1975. Line item number J66420 Stock No. 8415-00-227-1220 (small), 1221 (medium), 1222 (large)) which will allow people to handle metal and make fine adjustments as on artillery pieces, mortars and recoiless rifles.

6. MEDICAL EVACUATION AND MEDICAL SUPPORT

6.1. A medical setup has to be located close to the troops, particularly when there is no air superiority.

6.2. The ahkio should be used for short distance evacuation only -- up to 500 meters -- unless unusual circumstances exist.

6.3. An evacuation by ahkio normally requires four men and is very difficult.

6.4. In the cold, because of the additional clothing and physical requirements, the energy output is tremendous. If large distances have to be traversed, relief and security teams will have to be provided because of the excessive requirement for personnel and the mission accomplishment may be jeopardized.

6.5. In the event of several casualties, a triage system may be the most important. Someone will have to decide who gets aid and evacuation first and who has to wait.

6.6. Some rescue teams (non-military) use a covered sled for evacuating injured people.

6.7. A new medical aidbag is needed which rolls out to let the medic see all his gear.

6.8. Few people were very confident that helicopters would be available in future conflicts. In the cold there is a lot of down time due to weather. In this event, a heated ambulance will be essential.

6.9. Speed and careful handling are needed for the evacuation of casualties. Both are extremely difficult to achieve in the cold due either to lack of helicopter availability or to the lack of a heated ambulance.

6.10. There are often not enough medics to staff an aid station and to take care of field medical duties. A medical unit often has to sacrifice part of its field personnel to support an aid station. It takes more people to get a job done in the cold.

6.11. Normally everybody in a medical unit is doing double duty -- seldom is a medical unit full strength.

7. PSYCHOLOGICAL FACTORS IMPORTANT IN COLD

7.1. People who keep moving survive better and have less injury.

7.2. Units in the cold usually get less sleep and are more tired at night due to the physical demands and the requirement to keep vehicles running all night.

7.3. People have a tendency to relax military discipline and security when providing for their own comfort. An example of this is setting up camp and getting warm before setting up security around the camp.

7.4. People initially move out with too much clothing and gear and will often end up throwing some of it away.

7.5. "Psychologically," people give up when injured in the cold.

7.6. When people get tired and cold, they say "to hell with it" and their behavior deteriorates.

7.7. Men have to be kept busy. If they are not active they will get cold and morale will deteriorate.

7.8. Some groups work better together than other groups in a stressful situation because of their closeness.

7.9. When working together in the field, people have to take care of each other. This is the essence of the buddy system.

7.10. People looking after each other will prevent many cases of frostbite.

8. OPERATIONS

8.1. Although cold weather warfare manuals provide excellent information on individual functioning little information is available on maintaining and improving unit performance.

8.2. Tactics, as taught in the manuals, are not always applicable in winter warfare. Examples:

8.2.1. Firing positions using ski poles take too long to set up and are generally impractical.

8.2.2. You have to get rid of your skis when you have been fired upon. It would then be nice to have snowshoes available.

8.2.3. A unit which has been fired upon in a snowbound terrain often cannot attack. It must wait for another unit to come.

8.2.4. You do not fight the same way in winter as you do in the summer. Example: You cannot charge up a hill on skis.

8.3. Operations should be out of a series of base camps instead of a single large logistic facility.

8.4. There is greater danger of injury due to weapon malfunctions such as slow burning fuses, duds, longer back blasts.

8.5. The first few rounds fired in very cold weather will be off target due to distortion of the metal. As the metal warms, accuracy can be improved. The problem recurs as the gun cools.

8.6. Everything is slowed down in winter.

8.7. In the cold, you have to recognize that there is a different rhythm to things.

8.8. Some tactics cannot be applied in the cold -- operations are at least twice as slow in the cold as in normal temperature. A unit can move only about one kilometer/hr in a snow-covered cold environment.

8.9. You have to have detailed plans for cold weather operations.

8.10. There is no difference in the basic jobs that must be done in cold. However, everything takes longer and is more difficult to accomplish.

8.11. To keep a unit going for a long time in the cold, you may want to establish some kind of a rotation system. Otherwise, people will tire soon.

8.12. The key problem is planning.

9. CLOTHING

9.1. The most common complaint voiced was that the clothing was too heavy. Everyone wanted lightweight clothing.

9.2. Many people felt that non-wool thermal underwear and black ski gloves were acceptable substitutes for the military clothing.

9.3. It was observed that even experienced individuals did not correctly wear the cold weather clothing.

9.4. It is hard to keep headgear on people, especially when their heads begin to sweat.

9.5. Some people thought it would be helpful if the Army would authorize the wear of a turtleneck sweater.

9.6. A trigger finger glove with increased dexterity is needed.

9.7. Personnel should be given a complete issue and well-fitting issue of clothing. Extra time should be taken at the Central Issue Facility to insure that troops, particularly inexperienced troops, are given properly fitting clothing.

10. EQUIPMENT

10.1. The most frequently mentioned needed improvements were to lighten the clothing load and do something to keep equipment from failing at low temperatures (vehicles, batteries, radios).

10.2. Batteries, radios, vehicles all could use improvement.

10.3. Communication equipment is always difficult to operate in the cold.

10.4. The biggest problem with the weapons is lubricants.

10.5. It is mandatory that the Yukon stove be turned off at night -- a fire guard will probably go to sleep.

10.6. Every piece of equipment has to be prechecked, especially the Yukon stove.

10.7. The binding (for cross-country skiing) must come up high at the heel or a tremendous amount of energy will be wasted.

10.8. Most people thought that some Army skis and bindings were obsolete and that better equipment was available.

10.9. The lack of a safety release mechanism on some ski bindings causes a lot of injuries in troops, particularly during the early stages of training.

10.10. There was a lot of disagreement on which types of skis should be used in each situation.

10.11. The military canteen is practically useless in the cold because of the problem of freezing.

10.12. Some troops use a wine skin that can be carried comfortably next to the body under the uniform.

10.13. The metal canteen sticks to the lips at very cold temperatures. It has the advantage that it can be placed directly on the Yukon stove in order to melt the ice.

10.14. Perhaps what is needed is a metal canteen with a plastic mouthpiece.

10.15. Troops need to be issued a face mask, arctic mittens, and arctic canteen when they are in cold weather training.

10.16. People in the continental U.S. feel that Alaskan troops have the better cold weather equipment.

11. VEHICLES

11.1. Considerable discussion was held concerning the advantages and disadvantages of using snowmobiles in cold weather military operations. The disadvantages included:

11.1.1. They will not operate in deep snow.

11.1.2. They must operate on a fairly level plain.

11.1.3. The maintenance is difficult -- they are not "soldier-proof."

11.1.4. The pulling power is limited. They will not climb steep grades with a load.

11.1.5. They are noisy.

11.2. The advantages included:

11.2.1. They can be used for breaking trail and for ahkio pulling.

11.2.2. They are extremely maneuverable in wooded areas where large vehicles cannot be employed.

11.2.3. They provide rapid mobility.

11.2.4. While not an advantage, in winter you have to use anything that will go, even if it is not the best possible vehicle.

11.3. A heater is needed for water trailers to keep the water from freezing.

11.4. Persons who sit or sleep in vehicles with the engine running (this frequently applies to medics) run a high risk for carbon monoxide (CO) poisoning.

11.5. In the cold, tires go flat and fuels get thick. Periodic starting of vehicles is necessary.

11.6. Tracked vehicles can traverse snow of greater depth than wheeled vehicles, but this depends on the condition of the snow, the vehicle, and the terrain. Regardless of the vehicle, movement is difficult.

11.7. Tracked vehicles build up snow underneath and cannot turn.

11.8. Planning for the use of vehicles must be done carefully and must include alternate plans.

11.9. Lubricants for vehicles and weapons are of great importance in assuring the success of a mission.

12. LOGISTICS

12.1. Air superiority (or perhaps parity) will be essential for air evacuation and resupply.

12.2. If helicopters are used in future conflicts or training in cold environments, they should be deployed from a fixed base where proper maintenance can be performed. Helicopters can be used for troop movement and resupply, but they are not totally reliable and, if you lose your fixed base, you will not have them at all.

12.3. We cannot assume the luxury of air mobility in future conflicts.

DISCUSSION

At the beginning of this report, 15 key questions were listed to which we sought answers during the field observation period. These were general questions and most have no clear-cut answers. The individuals who were interviewed were asked their opinion on most of them and wide range of answers was obtained. Many of these questions are situation and person-specific. That is, depending on a number of interacting factors (including people) the answers will change. Perhaps that is one of the conclusions to be drawn from this study. We considered these questions as recurring. They might be used by any unit, whether or not it is accustomed to operating in the cold, as a means of maintaining a high level of unit performance.

We will attempt our own answers to these questions. The reader should note that these are only our opinions and one might formulate his own answers just as we have.

1. How does cold affect the medical delivery system?

As with everything else in the cold, it slows down. Casualty acquisition and evacuation times are lengthened. Field treatment consists only of the most expedient techniques. In the absence of heated fixed facilities, the freezing of drugs and intravenous fluids, and difficulties with clothing are serious problems.

2. Is medical doctrine altered in order to provide medical care in a cold environment?

Although we have limited information in this, it is our opinion that it may be affected in terms of locations of aid facilities and triage of casualties.

3. Is the force structure of the unit medical support adequate in the cold?

Based on our observation and experience, it seems clear that the force structure is inadequate for effectiveness in a cold environment. Medical aidmen will have to be added and new vehicles provided if a high level of medical support is to be maintained.

4. How do casualties affect the performance of a unit and its ability to complete its mission?

Any casualties of a serious nature which occur in a unit operating in the cold will be of major importance. It will take a large ratio of healthy troops to casualties to evacuate the casualties or to keep them from freezing. The unit will have to evacuate to the medical facility or take protective measures (such as building a shelter or erecting a tent) while awaiting the arrival of the medics.

5. Is cold weather itself stressful to individuals?

There appears to be some fear on the part of people who have never operated in severe cold. However, proper training, practice and leadership can quickly overcome this initial anxiety. Confidence is built quickly in troops who are willing to work hard and learn. On the other hand, units with poor leadership and poor social bonds between people may never attain any real proficiency in the cold. Above all, it takes teamwork to be successful in the cold.

6. How is tactical doctrine applied in the cold?

This is a question for the unit commander, but we will make some of our own observations. The mission of the infantry or combined arms team does not

change in the cold compared to temperate climates; however, those units we have observed who were successful, slowed the pace which they normally set for their men. If speed is essential in accomplishing the mission, there probably will be a much higher number of casualties. It may be better to take it slower and arrive with a unit intact.

7. How does the cold affect the personal habits of the people and their ability to perform?

If there is not a high degree of personal and unit discipline, many units will observe a deterioration in the personal habits of the troops. This applies especially to personal hygiene, and food and water preparation. These activities are essential to good morale and health, but are very time consuming. Troops who are in the field for only a short time often tend to let these slide.

8. What happens in a true emergency situation?

We did not observe any true emergencies in our field work. A unit, even in a training situation, should always be prepared to meet emergencies because in the cold they can quickly become life-threatening. Once again, leadership and a good social organization will be of great importance in determining whether an emergency even occurs.

9. What seem to be the critical factors enabling a unit to work effectively in a cold environment?

These factors, in our opinion, are leadership, the development of social cohesiveness such that people truly look out for each other and adequate preparation including "hands-on" practice and physical conditioning.

10. What are people's attitudes and practices with regard to the use of alcohol in the cold?

Commanders should be aware that alcohol will probably be taken to the field in the cold. The most important effect appears to be its influence in affecting a person's judgment and ability to make correct decisions. It will almost always cause problems for a unit in the field.

11. What are the physical demands on people?

They are very rigorous. A unit in poor physical condition cannot expect to do well in the cold. A training program must be undertaken several months in advance before going to the cold. Exercises should be designed to develop

cardiovascular strength and endurance and promote flexibility of muscles and joints.

12. Has the unit received enough cold weather medical training to function effectively?

This is primarily addressed to unit medics, but must, of necessity be applied to everyone since there are not usually enough medics to meet requirements. Cold weather medical training includes normal emergency medical care, cold injury and the difficulties in performing medical duties in the field. This is a tough assignment for a unit aidman to accomplish. This is probably best done by teaching medical skills and allowing medics to practice in the field. Too often medics are forced to sit in ambulances waiting to pick up casualties instead of being out training with their unit. Individual soldiers should receive medical training as well as the aidmen. Medics are few in the field and some medical techniques should be taught to all troops.

13. What "life styles" seem to be conducive to performing well or poorly in the cold?

The methodical, careful, even-tempered person will probably succeed more than will the impulsive, quick tempered individual. Cold weather operations involve many small but necessary tasks, accompanied by a lot of frustration. The person who can adjust to this will be able to deal with cold weather operations more easily.

14. How knowledgeable is the individual soldier of the effects of cold upon him and does he know what personal care measures he can take to prevent cold injury?

Medical briefings of troops are probably much less effective than instruction to small groups in the field. Much of the material is difficult to remember and hard to understand until the individual has to confront it directly. Do not expect troops to be individually prepared until they have had experience and built confidence in themselves and their unit.

15. What are the physiologic effects of cold on individuals performing in the field?

Many troops will continue to perform well when they are very cold and have superficial frostbite. This was a surprise to some of us who thought these conditions would be incapacitating to most soldiers. This shows two points: (1) highly

motivated troops will keep going in the face of severe cold and personal discomfort, and (2) commanders should realize that injuries will occur in "hard charging" troops as well as the laggards. Being overdressed, overheating, and being in poor physical condition, will be some of the most common problems seen in training troops in the cold. Overheating is a condition which places the person at high risk for cold injuries because of the loss of clothing insulation due to sweating. It has been our experience that in this environment overheating, including actual heat injuries, are sometimes more common and more incapaciting than cold injuries.

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Appendix A

Energy Expenditure in Cold Weather Military Training

Cold Weather Military Training and Laboratory Studies of Work. The question of energy requirements of military troops performing in the cold has been a subject of scientific investigation since World War I[16,27] and is still an area of interest. Johnson and Kark[21] reported data collected during World War II on the voluntary food intake of soldiers in temperate, mountain, desert, jungle, arctic and subarctic climates. Ranges were from 3100 kcal* in the desert (92°F) to 4900 kcal in the arctic (-30°F). They reported a correlation between the average voluntary caloric intake and the mean environmental temperature to which the groups of men were exposed and felt the differences could not be explained in terms of body size, basal metabolic requirements or activity. It was hypothesized that the caloric expenditure was greater for a given task in the arctic because of the hobbling effect of arctic clothing and equipment and also that more heat was necessary to maintain thermal equilibrium. It was pointed out by Iampietro, Bass and Buskirk[20] that Johnson and Kark:[21] (a) did not correct caloric intakes for any weight changes which might have occurred, (b) physical activity was not well defined; and, (c) caloric intake was assessed by the mess inventory method which is a relatively gross technique. Johnson and Kark's data showed a 58 percent increase in caloric intake in going from a desert to an arctic environment (3100 kcal to 4900 kcal, respectively). It will be shown that this increase is much larger than what would be expected from the hobbling effect of clothing. This gross difference could have been due to either a tremendously increased work (activity) level or to increased appetite. If increased appetite was the cause of the large intake, it may have been due to factors such as boredom independent of the cold or the cold may have had a stimulating effect on appetite. This study became the reference for almost all post-World War II studies on energy balance in the cold.

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*The kilocalorie (kcal), a unit of heat is approximately the quantity of energy necessary to raise one kilogram of water one degree Celsius (or one pint, 4°F). A kcal is equal to 1000 calories or one Calorie. The calories referred to in food tables are actually kcals or Calories.

Gray, Consolazio and Kark[14] tested two subjects to determine if heavy clothing increased the energy output work (pedaling a bicycle ergometer) at a given temperature. They concluded that the cold environment produced about a two percent rise in the metabolism over a temperate climate and that a five percent increase was necessary in going from desert to temperate clothing and another five percent in going from temperate to arctic clothing.

Teitlebaum and Goldman[34] investigated the increase in energy cost for walking with seven multiple layers of clothing apart from that increase due to the added weight per se. Eight subjects walked at 5.6 or 8 kilometers/hr (km/hr), 3.36 or 4.8 miles per hour (mph), respectively, on a treadmill wearing the additional clothing or wearing it as a lead filled belt weighing 11.19 kg (24.67 lbs). An increased energy expenditure of 18 percent was found for the multiple layer clothing system over the belt at 5.6 km/hr and 14 percent at 8.0 km/hr.

Soule and Goldman[33] measured the energy cost per kilogram of a load carried on the feet at different walking speeds compared to a no load condition. The values reported were 4.2 times greater at 4.0 km/hr (2.4 mph) 5.8 times at 4.8 km/hr (2.88 mph) and 6.3 times at 5.6 km/hr (3.36 mph). The hobbling effect of arctic clothing may be considerably greater than 5 percent depending on the weight of the clothing and where it is distributed on the body.

Howe and Berryman[17] estimated average caloric intake of troops in U. S. Army training camps from 1941-43, to be an average of 3785 kcal with a range of 3000-4000 kcal. They noted that seasonal variation caused no more than a 400 kcal deviation with caloric intake being highest in the fall. A study of British infantry recruits estimated daily energy consumption (intake) at 3850 kcal and the expenditure at 3750-kcal[13]. A study of ad libitum (unrestricted) food intake by soldiers undergoing advanced branch training found an average con sumption of 3669 kcal/man/day with an average weight gain of 2.03 kg (4.48 lbs.) over a 4 week period.[24] A parallel relationship was found between food intake and energy expenditure on the same day.

Rodahl[30] also reviewed the area of caloric requirements in the cold and noted that figures of 5500-6000 kcal/man/day had been suggested for men engaged in field operations as well as for troops in garrison in the arctic or subarctic. He reported that Greenland trappers maintained their body weight on 3000 kcal/day.

The miners in Spitsbergen working 8-3/4 to 9-1/2 hours a day gained weight on 4500 kcal. Crossing the Greenland inland ice on skis, two men consumed 4000 kcal daily and found this to be ample even under these strenuous conditions. Energy requirements of 65 kg (143 lb.) adult Eskimos were put at 2800-2900 kcal/day.

Field Studies of Energy Intake and Expenditure in the Cold. The results of a field study of heavy work in the cold[9] indicated that caloric intake was associated with the activity level and not with the outdoor temperature. The men were pulling a loaded sled (242 lbs) 10 to 12 miles a day as well as chopping ice, pitching tents, clearing snow and brush and performing routine bivouac activities. Average caloric consumption during three five day bivouac phases were 3902, 4199 and 4488 kcal/man/day. The highest single value was 6789 during the third bivouac phase. The authors concluded that the caloric intakes recorded during the bivouac periods were very close to the actual energy requirements. During the bivouac periods the mean intake was 4096 kcal/man/day. They recommended 4500 kcal/man/day for soldiers who are working hard and living on a self-sufficient bivouac basis.

A recent Canadian field study[2] estimated the energy expenditure of infantry troops participating in winter training in the subarctic at 3484 kcal/man/day. The ration provided 3600 kcal, enough to maintain caloric balance. A mean weight loss of 1 kg per man was noted for the exercise. These data suggest that a slightly higher caloric intake, say 3800 kcal/man/day, might have been justified for some individuals.

LeBlanc[25] surveyed the caloric requirements of persons living in the cold and taking part in military arctic exercises. The average value for food intake was about 3900 kcal/man/day. According to LeBlanc, direct and indirect evidence showed no correlation between environmental temperature for temperate, arctic and subarctic environments. Five experiments reviewed were considered to be overestimating the amount of food consumed (average of 4200 kcal).[4,5,6,7,22] The most accurate methods yielded food intake of 3600-3800 kcal.[10,26] LeBlanc also studied the energy expended in traveling on foot in the arctic or subarctic and concluded that the three main sources of energy expenditure were: (a) the direct effect of cold which would induce shivering, (b) the hobbling effect of clothing and (c) the difficulties of walking over arctic terrain. The first factor

is negligible for properly clothed men because shivering is prevented. For the second factor, the hobbling effect of arctic clothing, LeBlanc quoted the figure of five percent from Gray, Consolazio and Kark[14].

Recent work investigating the energy cost of walking over snow revealed a linear increase in energy expenditure with increasing depth of footprint depression.[29] At 45 cm (17.72 in.) footprint depression energy expenditure increased by a ratio of 5:1. All ten subjects were above average in fitness and terminated walking due to exhaustion at an average footprint depth of 35 cm (13.78 in.) and a walking speed of 2.5 mph. Practical limits were suggested. For persons walking without snowshoes at 50 percent of their maximum effort (a high work load) 20 cm (7.87 in.) was the suggested limit for a speed of 1.5 mph and 10 cm for 2.5 mph. At increased footprint depths, the authors suggested the limiting factors for snow walking were the increasing lift work, inefficient stooping posture and balancing difficulty.

Rodahl[30] studied infantry and Air Force personnel during the four seasons on garrison duty in Alaska and Eskimos in four different locations. The gross consumption of the infantry soldiers was 3100-3400 kcal with an average of 3200 kcal. The average caloric expenditure was 2800 kcal, with a mean weight gain of 0.4 lbs. throughout the year. For the airmen, the gross consumption was 2000-3000 kcal/man/day (average 2950 kcal). The mean energy expenditure was 2700 kcal. The adult male Eskimos had an average gross consumption of 3100 kcal and a mean daily energy expenditure of 2700 kcal. He concluded the requirements for troops on arctic duty to be in the area of 3000-3500 or slightly higher. He pointed out that most of these figures have been based on experienced arctic travelers who may cover the same ground with much less effort than an untrained person who does not possess the know-how and techniques of arctic travel. It was also stated that there was no reason to expect an increased caloric requirement because of increased basal metabolism due to climate.

Military studies found men living in the subarctic consumed 600-800 kcal/day more than the desert group.[10,19] Activities performed were similar in both groups. They concluded that this was due to an increased energy expenditure largely due to the encumbrance of arctic clothing and differences in terrain and ground cover over which the men walked rather than to an effect of cold.

Welch, Buskirk and Iampietro[36] investigated the impact of climate (temperature) on caloric intake in hot, temperate and cold climates. Activity was uniform in the hot and temperate climates consisting of a 9-10 mile march over level terrain, but heavier in the cold (9-12 mile daily sled pull). They found caloric intake, expressed on the basis of body weight*, to be independent of ambient temperature. The caloric intake for heavy work (in the cold climate) was 60 to 62 kcal/kg body weight while for moderate work (temperate and hot climates) was 47 to 49 kcal/kg. For a 70 kg man (154 lbs.) this would be 4340 kcal and 3430 kcal, respectively, for heavy and moderate work. This difference was based on the total weight being transported and on the distribution of the weight. They noted that the greatest relative increase in energy expenditure was produced by the heavy footgear, since weights on any extremity markedly affect energy expenditure[15]. A figure of 4.31 kcal/hr was noted for walking at 3.41 mph over level terrain in the cold. They concluded that climate affects the caloric requirements by modifying the daily physical activity rather than by an effect of temperature per se on the metabolism of the person.

Hughes and Goldman[18] found that subjects carrying a load of up to 60 kg (132 lbs.) on a treadmill tended to adjust their energy expenditure (work level) to a 425 kcal/hr ±10%. It was suggested that men tended to work with a fairly typical upper range of energy costs in the range of 400-450 kcal/hr regardless of variation in the load or the difficulty of the terrain.

Effect of Cold Stress on Caloric Intake. Iampietro, Bass and Buskirk[20] in a laboratory study of cold stress attempted to eliminate clothing and activity as variables in order to see the effects of cold stress per se on caloric intake. Five men wearing shorts lived in a room at 60°F for two weeks with minimal activity. The temperature of 60°F produced a marked subjective discomfort, shivering and a decreased skin temperature. This type of study produces chilling

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*Many publications use weight (actually mass) as an index of metabolic rate, the higher the weight the higher the metabolic rate. This is not thought to be a good index by some authors since persons of identical weight may have different body types and weight distributions. A better measure is body surface area expressed in square meters[32]. If height and weight are known surface area can be computed from the equation:

Area (m^2) = 0.202 x weight (kg)$^{0.425}$ x H$^{0.725}$ Nomograms are available for easy translation[12,32].

that is more severe than what is actually experienced by persons in subarctic or arctic conditions who are properly dressed and exposed to cold for only short periods of time. The men ingested an average of 525 kcal/man/day more in the cold than in control and recovery periods (80°F). Resting energy expenditures were 2661, 2870 and 2687 kcal/man/day, respectively, during the control, cold and recovery phases, the cold period showing an average increase of 196 kcal/man in the cold period. The increased caloric intake was associated with an increase in the measured resting oxygen consumption which was the result of increased muscle activity (frank shivering and non-detectable shivering). More severe chilling, such as might occur in a survival or disaster situation, should cause greater energy expenditure due to the increased exertion required to maintain body temperature. There was no evidence of cold stress imposing additional caloric requirements apart from those resulting from increased muscle activity.

Energy Requirements for Survival. A study of simulated survival situation[31] subjected 12 men to five days of starvation in the subarctic winter. The men were adequately clothed and built shelters from parachutes and willow sticks on the first day of exposure. The caloric cost was 2300 kcal/m^2 for the first day (4500 kcal) and 2000 kcal/m^2 for the subsequent days (3930 kcal). The value for day 1 is probably due to the work involved in constructing the shelter and activity necessary to keep warm. The values for subsequent days are for activity related to relieving the thermal stress alone since the shelter was already built. They recommended that rations for a solitary survivor should be in the range of 4500-5000 kcal, at a minimum, because of morale factors and being able to perform enough vigorous activity to keep warm.

Effects of Reduced Intake on Performance. A British experiment[11] tested the effect of a reduced food intake on the military efficiency of nine soldiers on a 14-day patrolling exercise. Their mean daily energy expenditure was 3520 kcal/man/day and their intake was 1880 kcal/man/day. Their performance and physical work capacity were compared with a control group who had an intake of 3470 kcal/day. At the end of 14 days, no differences were found between the two groups on performance, but during the last three days a dulling of arousal in terms of increased lethargy was noted. For four days after the test, the low calorie group was fed ad libitum (at their pleasure) and had a mean daily intake

of 6330 kcal. Their performance during this period was less proficient compared to the control group at the end of this period. The authors concluded that for a period of 10 days duration a ration of 1900 kcal/day will be sufficient for soldiers required to do hard work, but further experimental work is needed on this question.

The Minnesota subjects in studies[23] of semi-starvation (average weight loss of 24 percent, average intake of 1570 kcal/day over a 24 week period) showed symptoms of depression, apathy, nervousness, irritability and general emotional instability. The semi-starvation promptly and steadily produced a decline in basal oxygen consumption. Also produced were bradycardia (mean pulse rate of 32 men was 40.8 with a range of 31-58 beats per minute) and a depression of peripheral circulation which was not normal. Coldness of the skin and increased sensitivity to cold were common. The maintenance of the capacity for physical work was affected depending on the necessity for strength and endurance on the one hand and coordination and speed of movement on the other. Strength and endurance, particularly endurance, were greatly affected. Speed and coordination were more resistant to semi-starvation.

Recovery, both physical and psychological, of total fitness was much slower than expected.

These studies of undernutrition show that troops can perform well for short periods of time on drastically reduced intake. However, alterations in mood will occur early and reduced physical capacity will occur if the duration is beyond the minimum. Also, recovery period must be planned for troops who are on this type of regimen.

It should be noted that all the studies cited here have men as the subjects. There is no reason to believe that women doing the same kind of work as men would require fewer calories if body sizes are approximately similar.

Current Guidelines. Current Army Regulations follow the guidelines of the National Academy of Sciences/National Research Council publication, "Recommended Dietary Allowances",[28] with adjustments to meet the needs of military personnel. The number of calories recommended are 3200 for men and 2200 for women. However, additional allowances are made in paragraph 4.c, of AR 40-25 which is quoted here:[3]

"The recommendations are established for military personnel moderately active and living in a temperate environment. Individuals engaged in heavy labor for extended periods of time may increase their energy requirements by more than 25 percent. In rare instances, where troops are undergoing sustained vigorous physical activity, the daily calories expenditure may exceed 4800 k calories. More often, personnel will have reduced requirements because of lessened physical activity. The correct caloric allowance for an individual maintains has body weight at a level consistent with his well-being and physical efficiency."

The Army's most current technical manual on nutrition[35] similarly notes that the usual upper limit for men at heavy work will be 3800-4000 kcal. For extremely heavy work the values 4800-5000 kcal are given, but the reader is cautioned that this level is rarely encountered and usually represents a temporary need. This manual notes that a slight increase in calories may be necessary for men undergoing the same physical exercises in the arctic compared to temperate climates due to the hobbling effect and weight of Arctic clothing, especially the footgear.

Summary and Conclusions. A table is provided (Table 1) to summarize the literature reported here on energy balance in the cold.

Table 2 is provided to show one possible distribution of the energy values that might occur to produce a caloric requirement of approximately 3900 kcal/man/day.

An energy intake of 4000 kcal/man/day should be sufficient to maintain nearly all troops undergoing moderately rigorous winter training. Considerably, lower values would probably not be at all detrimental to many of those of smaller body dimensions.

If this energy level cannot be provided, there is reason to believe that troops can perform well on lower energy intakes[11] for a short period of time, say not to exceed 10 days. However, psychological factors may impact on morale, leadership and social interactions.

High fat and high carbohydrate diets have been recommended for providing

protection against heat loss in the cold[8] with high fat being slightly superior. A high protein diet was considered definitely less effective. Studies of American troops[30] have found that the average composition of the diet is not changed in going from a temperate to a cold climate: 13% protein, 38% fat and 49% carbohydrate. It is recommended that the percentage of fat be kept at not above 35% due to the increased risk of atherosclerosis. A sufficient number of calories can be obtained from increased carbohydrates (50%) without the risk imposed by a high fat diet. People are sometimes encouraged to "fatten up" before going to the cold because of the increased insulation provided by subcutaneous fat. It is likewise recommended that this procedure not be followed. In man, subcutaneous fat is negligible as an insulator against cold air compared to clothing. (Fat persons subjected to prolonged exposure to cold water may have increased survival rates, but this is hardly a good reason for becoming overweight). The reverse should be done; that is, a person should trim down and increase his physical fitness before under taking even moderately strenuous physical activity in the cold. There is evidence that persons having a higher fitness level maintains higher skin temperatures than non-fit persons.[1] Fit persons are also able to do more work and thus generate more body heat than the non-fit.

In summary, it is recommended that persons preparing for military winter training alter their diet only to compensate for increased work levels, maintain a well balanced diet with a lot of variety to allow proper intake of nutrients, and minerals and maintain a high level of physical fitness.

Table 1. Reported Values for Energy Balance in the Cold

Type of Activity	Caloric Intake (kcal)	Energy Expenditure (kcal)
Normal military training		
Temperate conditions	3520[11]	3470[11]
	3750[13]	3850[13]
Cold	3484[2]	3785[2]
	3279[24]	3669[24]
Garrison Troops		
Cold	2950-3200[30]	3000-3500+[20]
Moderate Work, Cold		3430[9]
Heavy Work		4340[34]
Eskimos	3100[30]	2700[30]
Explorers	4000[30]	
Trappers (low activity)	3000[30]	

Table 2. Approximate Energy Costs for Activities in Typical Winter Military Training.

Activity	Approximate Metabolic Rate	Time(hrs)	Energy Cost
1. Heavy activity (heavy work)	425.0 kcal/hr[18]	4	1700.0 kcal
2. Moderate activity (e.g., walking)	186.0 kcal/hr[35]	4	746.0 kcal
3. Light activity	156.0 kcal/hr[35]	4	624.0 kcal
4. Resting (e.g., eating, sitting)	90.0 kcal/hr[35]	4	360.0 kcal
5. Sleep	69.6 kcal/hr[35]	8	557.0 kcal
		TOTAL	3987.0 kcal

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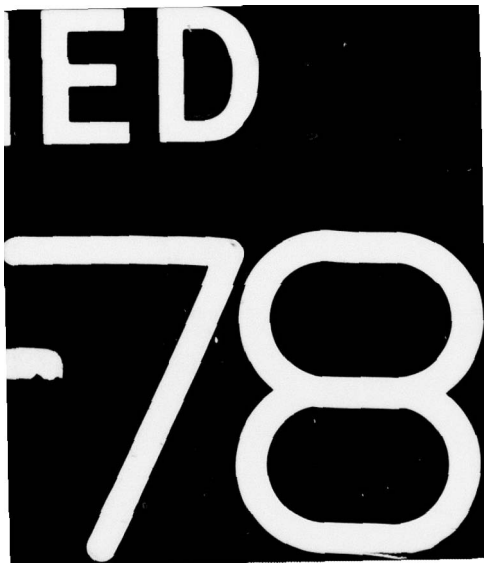
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